

# **METHOD OF MANUFACTURING A FLASH MEMORY DEVICE**

## **BACKGROUND OF THE INVENTION**

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### **Field of the Invention**

The present invention relates to a method of manufacturing a semiconductor device, and more particularly, to a method of forming a sidewall oxide films for protecting a gate electrode at the sidewall of the gate  
10 electrode in a flash memory cell.

### **Background of the Related Art**

In general, in implementing the flash memory devices, after the gate electrode is formed, a dry oxidization process using O<sub>2</sub> is implemented for the  
15 gate sidewall in order to compensate for etch damage obtained when the floating gate is isolated and gate is etched. At this time, it is advantageous to thickly form the sidewall oxide films formed by sidewall oxidization from the viewpoint of sidewall reinforcement and compensation of etch damage. In order to form a thick sidewall oxide film, however, an oxidization process is  
20 performed for a long period of time. Thereby, a smiling phenomenon occurs that the thickness around the sidewalls of first and second oxide films and a tunnel oxide film among the dielectric film of a first oxide film/a nitride film/a second oxide film (oxide/nitride/oxide, ONO) structure that has been widely used as the dielectric film in the flash devices is increased. This causes to

degrade characteristics of the device.

### **SUMMARY OF THE INVENTION**

Accordingly, the present invention is contrived to substantially obviate  
5 one or more problems due to limitations and disadvantages of the related art.

An object of the present invention is to provide a method of manufacturing a semiconductor device capable of prohibiting a smiling phenomenon by implementing dry oxidization using an adequate mixed ratio of O<sub>2</sub> and TCA (tri-chloro-ethane, C<sub>2</sub>H<sub>2</sub>Cl<sub>3</sub>) in a sidewall oxidization mode/.

10 Additional advantages, objects, and features of the invention will be set forth in part in the description which follows and in part will become apparent to those having ordinary skill in the art upon examination of the following or may be learned from practice of the invention. The objectives and other advantages of the invention may be realized and attained by the structure  
15 particularly pointed out in the written description and claims hereof as well as the appended drawings.

To achieve these objects and other advantages and in accordance with the purpose of the invention, as embodied and broadly described herein, a method of manufacturing a flash memory device according to the present  
20 invention is characterized in that it comprises the steps of providing a semiconductor substrate in which a gate electrode including a tunnel oxide film, a floating gate, a dielectric film and a control gate is formed, and implementing a dry oxidization process using a mixed gas of O<sub>2</sub> and C<sub>2</sub>H<sub>2</sub>Cl<sub>3</sub> to form sidewall oxide films at the sidewalls of a gate electrode in order to

compensate for damage due to an etch process for forming the gate electrode and reinforce isolation of the floating gate.

In another aspect of the present invention, it is to be understood that both the foregoing general description and following detailed description of 5 the present invention are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

The above and other objects, features and advantages of the present 10 invention will be apparent from the following detailed description of the preferred embodiments of the invention in conjunction with the accompanying drawings, in which:

FIG. 1A and FIG. 1B are cross-sectional views of semiconductor devices for explaining a method of manufacturing the device according to a 15 preferred embodiment of the present invention;

FIG. 2A and FIG. 2B are SEM (scanning electron microscope) photographs showing that a sidewall oxide films is formed at the sidewall of a gate electrode using a conventional O<sub>2</sub> gas only; and

FIG. 3A and FIG. 3B are SEM (scanning electron microscope) 20 photographs showing that a sidewall oxide films is formed at the sidewall of a gate electrode using a mixed gas of O<sub>2</sub> and TCA according to a preferred embodiment of the present invention.

#### **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT**

Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings, in which like reference numerals are used to identify the same or similar parts.

5 FIG. 1A and FIG. 1B are cross-sectional views of semiconductor devices for explaining a method of manufacturing the device according to a preferred embodiment of the present invention.

Referring to FIG. 1A, a screen oxide film (not shown) that serves as a buffer layer for prohibition of crystal defects on the surface of the substrate or  
10 surface processing and ion implantation is formed on a semiconductor substrate 10. Ion implantation is then implemented to form a well.

After the screen oxide film is removed, a tunnel oxide film 12, a first polysilicon film 14 and a pad nitride film (not shown) are sequentially deposited. The pad nitride film, the first polysilicon film 14, the tunnel oxide  
15 film 12 and semiconductor substrate 10 are then sequentially etched through ISO (isolation) mask patterning, thereby forming a trench (not shown) of a STI (shallow trench isolation) structure to define an active region and a field region.

In the above, the first polysilicon film 14 is formed by depositing an undoped amorphous silicon film of a low oxidization resistance of 250 ~  
20 500 Å in thickness by means of a chemical vapor deposition (CVD) method, a low pressure CVD (LPCVD), a plasma enhanced CVD (PECVD) or an atmospheric pressure CVD (APCVD) method at a temperature of 480 ~ 550 °C and pressure of 0.1 ~ 3.0 torr.

A dry oxidization or wet oxidization process for compensating for etch

damage of the trench sidewall of the STI (shallow trench isolation) structure is implemented to make rounded the corners of the trench. Next, a high temperature oxide film (HTO) is thinly deposited on the entire structure and a densification process is then implemented at high temperature to form a liner 5 oxide film (not shown). It should be noted that the above process of depositing the liner oxide film might be omitted in order to simplify the process. A high density plasma (HDP) oxide film (not shown) is then deposited on the entire structure to bury the inside of the trench. Thereafter, a polishing process using the pad nitride film as a stop layer is performed to 10 remove the HDP oxide film 20 and the liner oxide film on the pad nitride film. An isolation film for isolating the devices is thus formed.

A nitride strip process using phosphoric acid ( $H_3PO_4$ ) is implemented to etch the pad nitride film. A pre-treatment cleaning process using DHF is then implemented to remove a native oxide film and the remnants formed on the 15 first polysilicon film 14. After a second polysilicon film 16 is deposited on the entire structure, a patterning process is performed to form a floating gate 18 consisting of the tunnel oxide film 12 and the first and second polysilicon films 14 and 16.

In the above, the second polysilicon film 16 is formed by depositing an 20 amorphous silicon film into which a P concentration of  $5.0E19 \sim 1.5E20$  atoms/cc is doped in thickness of  $1000 \sim 3000 \text{ \AA}$  by means of the CVD, LP-CVD, PE-CVD or AP-CVD method using  $SiH_4$  or  $Si_2H_6$  and  $PH_3$  gas at a temperature of  $480 \sim 550^\circ C$  and a pressure of  $0.1 \sim 3.0$  torr.

A dielectric film 24 is formed on the entire structure along its step,

wherein the dielectric film 24 having the ONO (a first oxide film 20-a nitride film 21-a second oxide film 22;  $\text{SiO}_2\text{-Si}_3\text{N}_4\text{-SiO}_2$ ) structure is formed. A third polysilicon film 26 being a material film for forming the control gate and a tungsten silicide ( $\text{WSi}_x$ ) film 28 are then sequentially formed. After a hard  
5 mask film 32 is formed on the tungsten silicide film 28, a patterning process is implemented to form a hard mask pattern. A self-aligned etch process using the hard mask pattern as an etch mask is then implemented to remove the tungsten silicide film 28, the third polysilicon film 26 and the dielectric film 24, thereby forming a control gate 30 consisting of the third polysilicon film 26  
10 and the tungsten silicide 28.

Or, the tunnel oxide film 12 and the first and second polysilicon films 14 and 16 for a floating gate are sequentially deposited on the semiconductor substrate 10 in which the isolation film (not shown) is formed. A patterning process is then implemented to etch the second polysilicon 16, the first polysilicon 14 and the tunnel oxide film 12, thus forming the floating gate 18.  
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The dielectric film 24, the third polysilicon 26, a metal film (tungsten silicide film 28) and the hard mask film 32 of the ONO structure are sequentially formed on the entire structure. A patterning process is then implemented to etch the hard mask film 32, the metal film 28, the third polysilicon film 26 and the dielectric film 24, thereby forming a flash memory  
20 cell including the control gate 30.

Those having skill in the art will appreciate that the present invention is not limited to the above embodiments but the gate electrode of the flash memory devices including the tunnel oxide film, the floating gate, the

dielectric film and the control gate could be formed through processes of various types for forming the flash memory devices.

By reference to FIG. 1B, a sidewall oxidization process is implemented to form a sidewall oxide films 34 for compensating for damage of an etch process for forming a gate electrode and isolating the floating gate 18, at the sidewall of the gate electrode of the flash memory device.

In the concrete, before the sidewall oxidization process, a pre-treatment process using SC-1 (standard cleaning - 1) containing NH<sub>4</sub>OH, H<sub>2</sub>O<sub>2</sub> and H<sub>2</sub>O is performed in order to prevent loss of the tunnel oxide film 12 and the oxide films 20 and 22 constituting the dielectric film 24 of the ONO structure. A dry oxidization process using a mixed gas of O<sub>2</sub> and TCA is then implemented to form sidewall oxide films 34 at the sidewalls of the gate electrode in the flash memory device. Next, the semiconductor substrate 10 in which the gate electrode is formed is loaded onto a chamber for an oxidization process at a temperature of 600 ~ 750°C. Oxidization is then implemented so that a sidewall oxide films 34 of 30 ~ 100Å in thickness is formed on the semiconductor substrate 10, by raising the temperature inside the chamber up to 750 ~ 950°C and then introducing an O<sub>2</sub> gas of 1 ~ 10slm and a TCA(C<sub>2</sub>H<sub>2</sub>Cl<sub>3</sub>) gas of 0.1 ~ 1slm into the chamber. Thereafter, the temperature inside the chamber is dropped and the semiconductor substrate 10 is then unloaded from the chamber. By doing so, sidewall oxidization having time shorter than conventional sidewall oxidization using only the O<sub>2</sub> gas could be implemented if the sidewall oxide films 34 of the same thickness is to be formed, since sidewall oxidization is smoothly performed but silicon within

the ONO and the tunnel oxide film is less oxidized due to a fast reaction speed (fast formation of the oxide film) by the TCA gas. It is thus possible to minimize ONO smiling and smiling of the tunnel oxide film. Furthermore, as 5 oxidization at the tip portion on the top of the floating gate that is made sharp due to influence had when the gate is etched is smoothly induced to cause oxidization of the same degree to the sidewall thickness, the charge retention capability of the device could be improved. The speed of oxidization using the TCA gas is faster by 10% than oxidization using only the O<sub>2</sub> gas.

FIG. 2A and FIG. 2B are SEM (scanning electron microscope) 10 photographs showing that a sidewall oxide films is formed at the sidewall of a gate electrode using a conventional O<sub>2</sub> gas only. FIG. 3A and FIG. 3B are SEM (scanning electron microscope) photographs showing that a sidewall oxide films is formed at the sidewall of a gate electrode using a mixed gas of O<sub>2</sub> and TCA according to a preferred embodiment of the present invention.

15 Referring to FIG. 2A, FIG. 2B, FIG. 3A and FIG. 3B, FIG. 2A and FIG. 3A are the SEM photographs of the sidewall oxide films formed in the dielectric film region of the ONO structure. FIG. 2B and FIG. 3B are the SEM photographs of the sidewall oxide films formed in the tunnel oxide film region. FIG. 2A and FIG. 2B illustrate the SEM photographs in which 20 sidewall oxidization processes are implemented using targets of 30 Å and 50 Å, respectively, by use of only an O<sub>2</sub> gas at a temperature of 850 °C. FIG. 3A and FIG. 3B illustrate the SEM photographs in which sidewall oxidization processes are implemented using targets of 30 Å and 50 Å, respectively, by use of a mixed gas of an O<sub>2</sub> gas and a TCA gas at a temperature of 850 °C.

From FIG. 2A, it can be seen that the oxide film is not formed in a sufficiently thick thickness at the sidewall of the dielectric film and the entire sidewall oxide films are unstable (not formed in a uniform thickness). On the contrary, from FIG. 3A, it can be seen that the sidewall oxide films of a sufficient thickness are formed at the sidewalls of the dielectric film and the sidewall oxide films of an entirely uniform thickness are formed. Furthermore, from FIG. 2B, it can be send that not only the oxide film of a sufficiently thick thickness is not formed at the sidewall of the tunnel oxide film but also the sidewall oxide films of a sufficiently thick thickness are not formed at the sidewalls of the first polysilicon film on the sidewall oxide film. On the contrary, from FIG. 3B, it can be seen that the sidewall oxide films of a sufficient thickness are formed not only at the sidewalls of the tunnel oxide film but also at the sidewall of the first polysilicon film.

As described above, the present invention has an advantageous effect that it can prevent a phenomenon that the thickness of the sidewall of the oxide film included within the dielectric film is thickened, by implementing a sidewall oxidization process using a mixed gas of O<sub>2</sub> and TCA. Also, the present invention has a new effect that it can secure a coupling ratio margin, by preventing a phenomenon that a total thickness of the oxide film included within the dielectric film is thickened through an oxidization process.

Furthermore, the present invention has a new effect that it can improve an entire operating characteristic of the device by reinforcing isolation of the floating gate and prohibiting a phenomenon that the thickness of the sidewall of the tunnel oxide film is thickened, through a sidewall oxidization process

using a mixed gas of O<sub>2</sub> and TCA.

The forgoing embodiments are merely exemplary and are not to be construed as limiting the present invention. The present teachings can be readily applied to other types of apparatuses. The description of the present invention is intended to be illustrative, and not to limit the scope of the claims. Many alternatives, modifications, and variations will be apparent to those skilled in the art.